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DISTRIBUTION OF SOME HARDWOOD DECIDUOUS TREES IN THE FRENCH ALPS *(Fraxinus excelsior L., Acer pseudoplatanus L., Prunus avium L.)* MULTILEVEL APPROACHES*

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SUMMARY

(original scientific paper)

In the french Alps some commercially valuable hardwood trees (ash, sycamore maple and wild cherry) colonise fallow land (farmely cultivated lands). With statistical and phytoecotogical approaches, we intended to establish how the species are distributed in the studied area.
In the external Alps, ash trees and sycamore trees are present in spruce, fir woodland and beech forest in large areas of low density. In the intermediate Alps the three species are well developed in fallow land and their density is higher. In the internal Alps, they are marginal. The relationship between spatial aggregation and density is different according to the geographic distribution and the soil biota activity involved.

KEY WORDS : French Alps - Commercially valuable deciduous trees - Ash - Sycamore maple - Wild cherry - Phytoecology - Humus - Soil fauna - Soil activity.

RÉSUMÉ

(travail original)

RÉPARTITION DE QUELQUES FEUILLUS PRÉCIEUX DANS LES ALPES FRANÇAISES (FRAXINUS EXCELSIOR L., ACER PSEUDOPLATANUS L., PRUNUS AVIUM L.). *APPROCHE MULTISCALAIRE.*
Dans les Alpes françaises à l'étage montagnard, des feuillus précieux (frêne, érable sycomore et merisier) colonisent les friches (anciennes terres cultivées). En intégrant conjointement des approches statistiques, phytoécologiques et pédobiologiques, nous avons essayé d'établir et de comprendre la distribution de ces espèces.
Dans les Alpes externes, les frênes et les érables sont disséminés, sur de vastes surfaces, dans les pessières, hêtraies et sapinières. Dans les Alpes intermédiaires, les trois essences sont bien développées dans les accrus avec une densité plus élevée. Enfin, dans les Alpes internes, leur présence est marginale. Nos travaux montrent ainsi l'influence déterminante qu'exercent la situation biogéographique et l'activité biologique du sol sur la répartition spatiale et la densité des feuillus précieux.

MOTS CLÉS : Alpes françaises - Feuillus précieux - Frêne - Érable sycomore - Merisier - Phytoécologie - Humus - Faune du sol - Activité du sol.

INTRODUCTION

The decay of land use since the last half century has caused arable land and cultivated fields to turn always more into fallow (BOZON & GROSSI, 1991). In addition, the reduce of the European Community over-production has increased this phenomenon. Today many fields have become permanently fallow. In fact, if no other management practices are supplied on the abandoned sites, natural succession begins (CONNELL & SLAYTER, 1977). Many studies show that vegetation dynamics has nowadays encouraged the development of deciduous plant formations with post-pioneer species : ash *(Fraxinus excelsior L.)*, sycamore maple *(Acer pseudoplatanus L.)* and wild cherry (*Prunus avium L)*. These trees are called « precious » because of their wood qualities.

This resource is already being managed in northeastern France. Meanwhile in the Alps only a few research projects deal with the spread of commercially valuable deciduous trees. These studies discuss only

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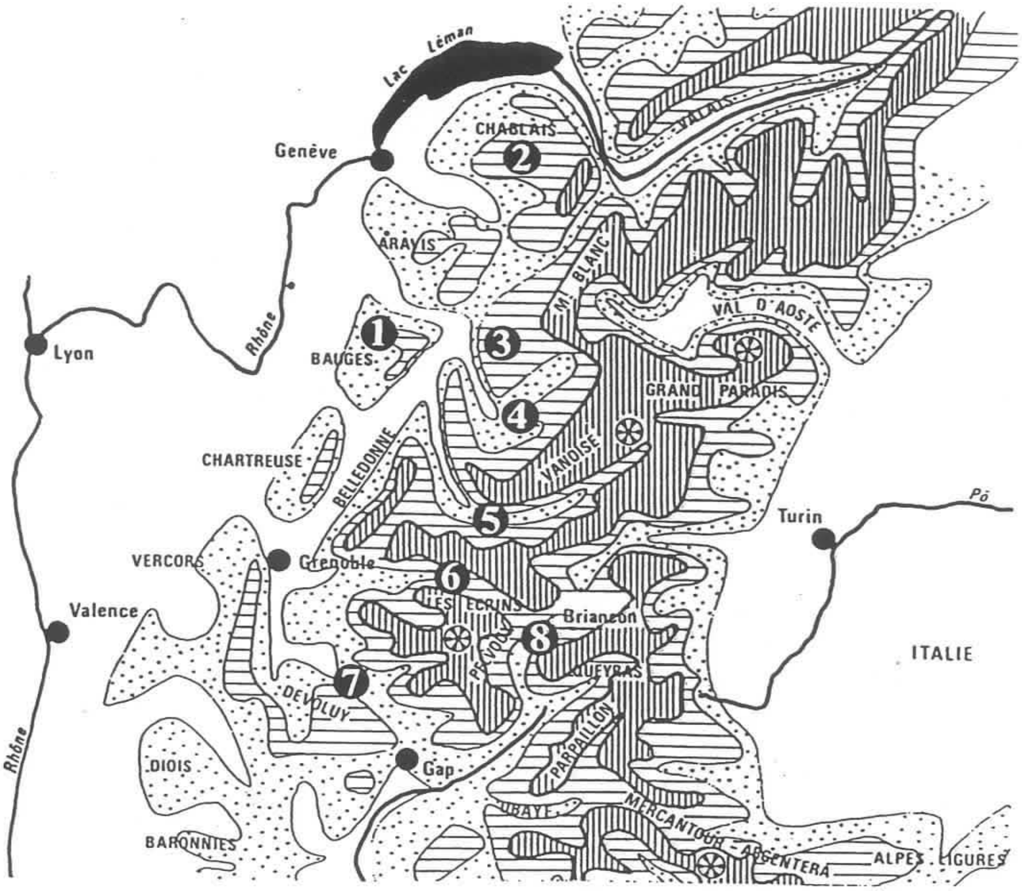


FIG. 1.– Studied areas localization.
1 - Bauges, 2 - Chablais, 3 - Beaufortin, 4 - Tarentaise, 5 - Maurienne, 6 - Oisans, 7 - Champsaur, 8 - Briançonnais.

Localisation des sites d'étude.
1 - Bauges, 2 - Chablais, 3 - Beaufortin, 4 - Tarentaise, 5 - Maurienne, 6 - Oisans, 7 - Champsaur, 8 - Briançonnais.

typological and floristic approaches (FOURNIER, 1985 ; MEYER, 1981). That is why we started to study other important aspects of this problem. Our aim here is also to establish how the commercially valuable deciduous trees are distributed in the French Alps according to environmental factors (climatology, biogeography, geomorphology and geology).

STUDY SITES

Therefore we intend to study the spatial distribution of hardwoods in the French Alps at the montane level and particularly in eight different areas from the external Alps to internal ones and from north to south (FIG. 1).

This mountain area presents various bioclimatic, geological and ecological conditions (OZENDA, 1983, 1985 ; OBERLINKELS, 1990).

We chose from among the eight areas three characteristic situations :

- Bauges (external Alps) : This area presents a contrasting landscape, with large forested surface (mixed forest) and a broad expanse of agropastoral land.
- Maurienne (intermediate Alps) : The mountainsides were used extensively for agropastoral activities until 1940, but today have been almost completely abandoned. All the landscape structure is made up of fallow land with deciduous trees.
- Briançonnais (internal Alps) : This site is

characterised by an openfleld structure. It was used for sheep grazing and nowadays the surface is colonised by xeric vegetation (coniferous forest).

METHODS

Our method is based on an ecologically oriented combination of statistical, phytoecological and pedobiological information.

Spatial distribution of hardwoods was established using the statistical data of « Inventaire Forestier National » upon several national forested areas⑴. The vegetation is mapped according to several planting types⑵.

Estimated stem number was used for each species and for characterising the distribution of the chosen species in each area. It was also used for describing to which different planting types each species belongs. These results are discussed after correcting them especially the densities with the surface area and the aggregation types.

Phytoecological aspect was studied using data extracted from the literature (RAMEAU, 1989, 1993). Several surveys were made in the different sites.

Humus profiles were described taking into account the litter types (quantity and quality) and some groups of the soil fauna [particularly earthworm species (Lumbricidae)].

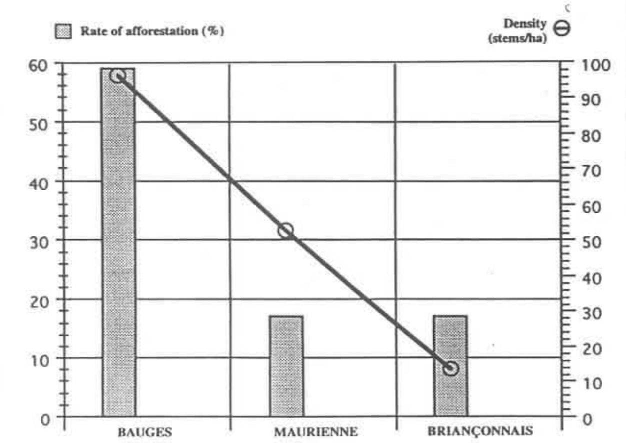


FIG. 2.– Afforestation rate (forested area / total area) and density (total stems number of the three species / forested area).

Taux de boisement (surface boisée/surface totale) et densité (nombre total de tiges des trois espèces/surface boisée).

RESULTS

STATISTICAL APPROACH

Statistical data allow us to estimate quantitatively the regional resource of commercially valuable deciduous trees, to situate it with others species and to analyse its geographic distribution (HOUILLER & RITTIÉ, 1992).

Our first result concerns the afforestation rate and the mentioned species distribution (FIG. 2).

In the Bauges region (FIG. 3a), the afforestadon rate is high (59,1 %). This can be explained by the climatic conditions (high rainfall contributing to increase dynamics

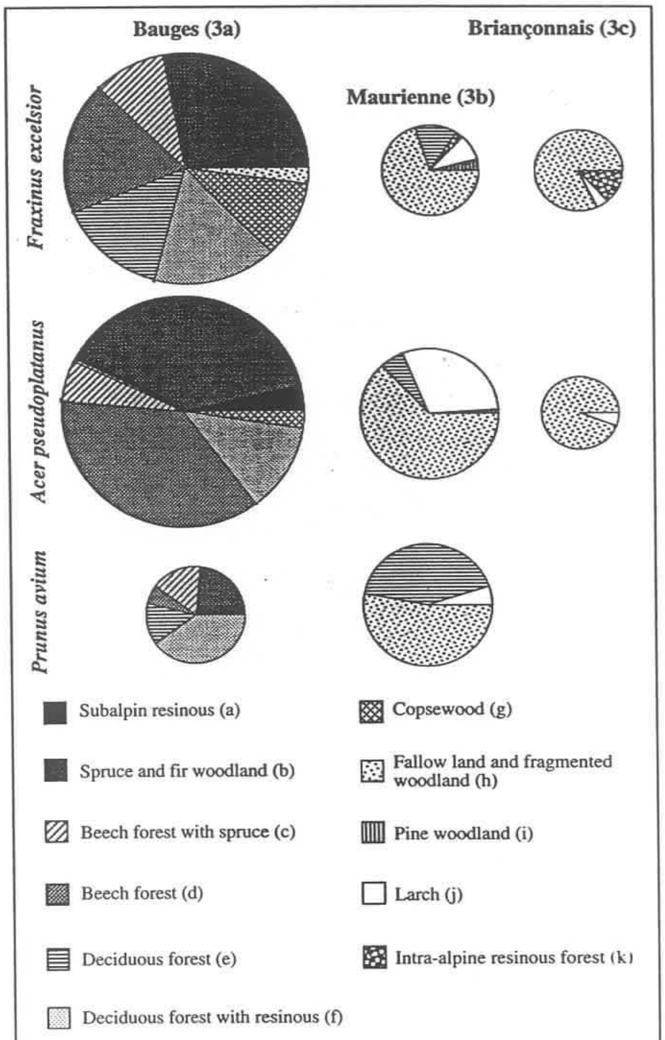


FIG. 3.– Species distribution in planting types. The figure size is proportional to the square root of total stem number.

Répartition des espèces en fonction des types de peuplements. La taille des figures est proportionnelle à la racine carrée du nombre total de tiges. (a) Résineux du subalpin, (b) Pessière et sapinière, (c) hêtraie mêlée d'épicéa, (d) hêtraie, (e) forêt feuillue (f) forêt feuillue en cours d'enrésinement (g) taillis divers (h) accrus et boisements morcelés, (i) peuplement de pin, (j) mélézin, (k) forêt résineuse intra-alpine.

⑴ National forested area : territorial division presenting similar forested conditions.

⑵ Planting types : planting unity showing an homogeneity of species (« Type de peuplement »).

of climax species : *Fagus silvatica L., Picea abies (L.) Kast., Abies alba Mill.).* The ash trees and sycamore trees are in the spruce and fir woodland and beech forest in large areas with low density (only 20 to 50 stems per hectare).

There are less wild cherry trees in total spread over large area.

In the Maurienne valley, the afforestation rate is lower (17,2 %). The commercially valuable deciduous trees are well developed in fallow land. Their density is higher (more than 100 stems/ha) and they cover a greater surface without being mixed with the mature stage species (FIG. 3b).

The Briançonnais is characterised by a nearly total absence of deciduous trees (only 2,5 % of the forested area which represent 17,2 % of the total area). The wild cherry is missing because of the altitude (more than 2000 meters on average, the average altitude in the French Alps).

Fraxinus excelsior L. and *Acer pseudoplatanus L.* are present in fragmented woodland areas, their density is low (less than 8 stems/ha). So, we can say that their presence is marginal (FIG. 3c).

PHYTOECOLOGICAL APPROACH

These three deciduous species are grouped in several floristical units according to the IFN data (as for example beech forest, spruce and fir woodland, fallow land...). The phytosociological position of the commercially valuable deciduous trees is explained in figure 4.

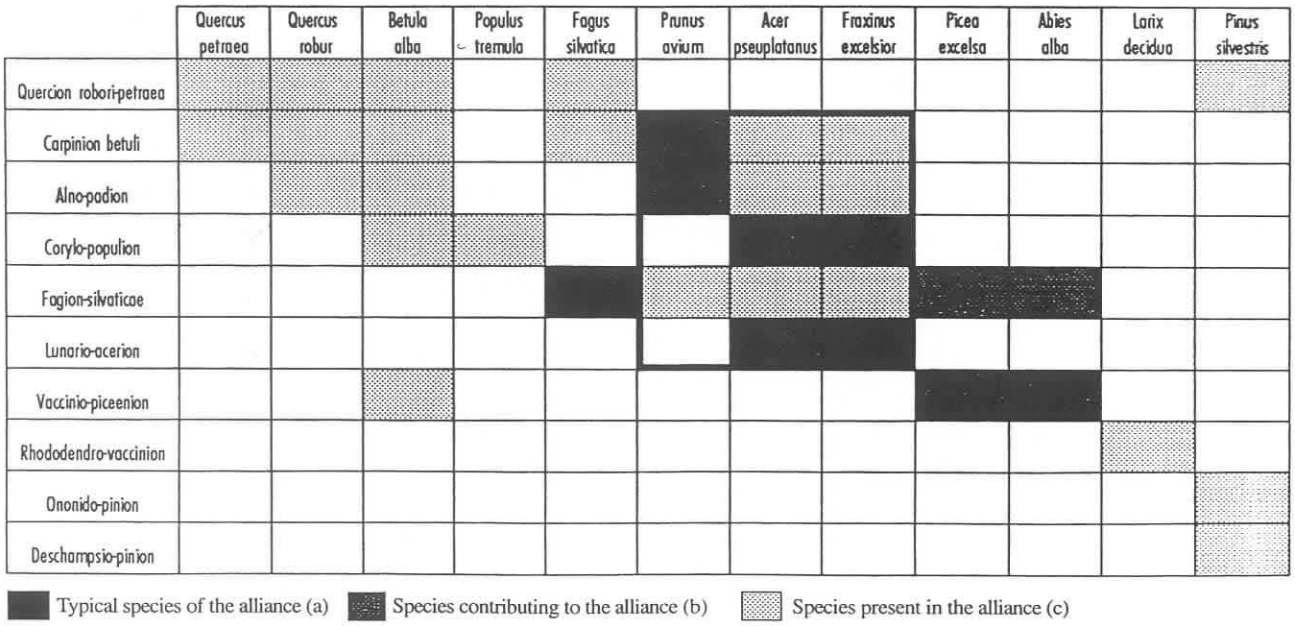
We have brought together all the species mentioned in the previous paragraph, trying to point out their contribution or their role in the phytosociological alliance.

As we can see *Fraxinus excelsior, L., Acer pseudoplatanus L., Prunus avium L.,* are representative of an intermediate situation. They are able to grow from the hill belt to the subalpine one, especially the ash, and the sycamore maple. In addition these three species were favoured by human activity (agriculture and grazing), kept in the hedges (the foliage was used to feed animals when field grazing was insufficient).

In the montane belt, the hardwood deciduous trees belong to some phytoecological successions. They are well located inside vegetation series in the external Alps (beech-fir series) and in the internal Alps [intra-alpine scots pine series (south-facing slopes) or montane larch forest (north-facing slopes)].

On the other hand, the intermediate Alps show a particular situation : it's the eastern distribution limit for *Fagus silvatica L., Picea abies (L.) Kast.* and the western one for *Pinus silvestris L.* and *Larix decidua Mill.* The studied species, showing hardly any competition, find here a favourable situation. It is difficult to classify them into series « *ces (...) groupements riches en espèces transgressives des associations voisines (...) sont difficiles à caractériser d'un point de vue phytosociologique* » (FOURNIER, 1985).

Much of the explanation for their widespread distribution rests with the great plasticity of the ecological requirements of these three species, combined with human actions.

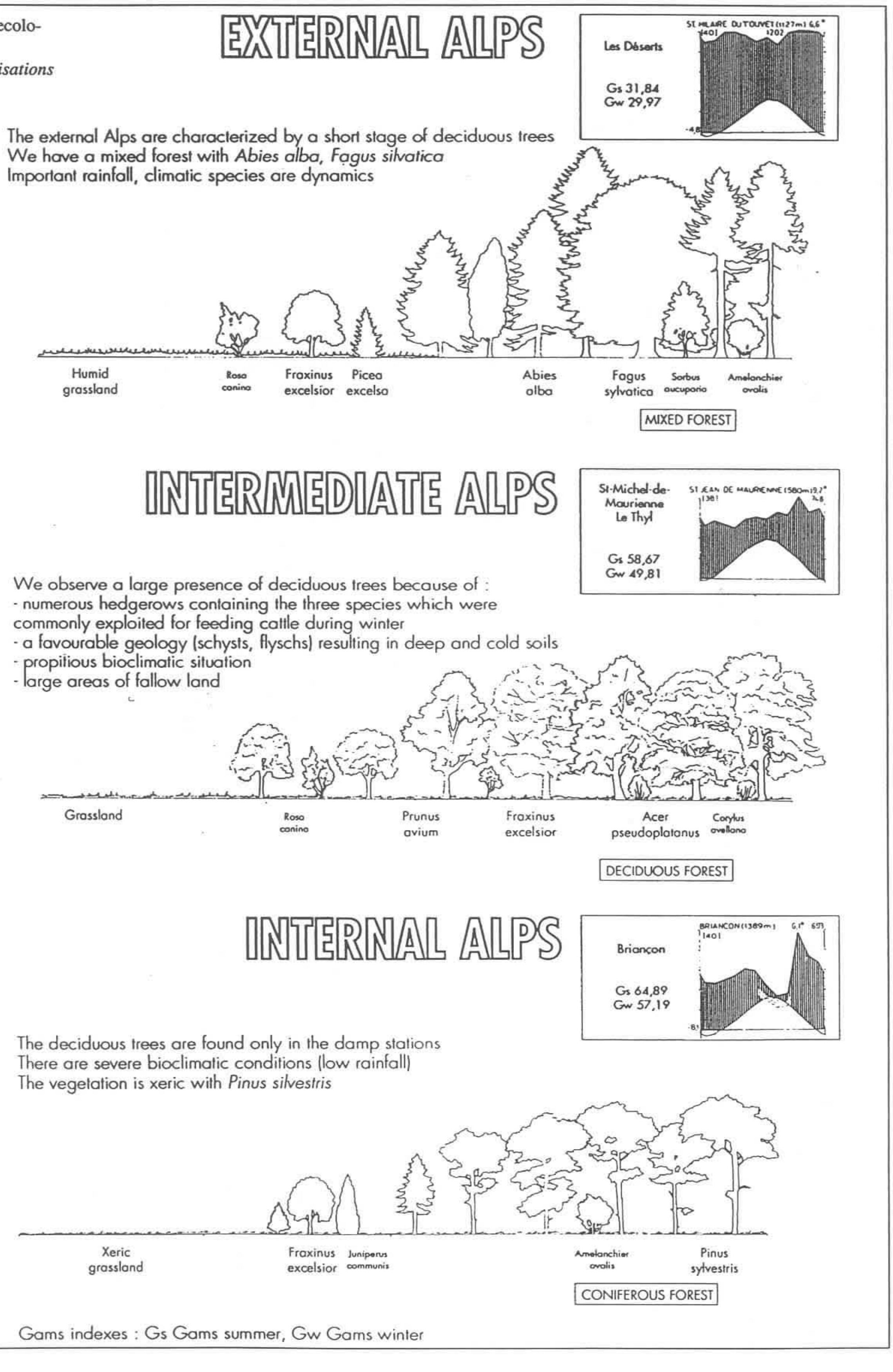


	Quercus petraea	Quercus robur	Betula alba	Populus tremula	Fagus silvatica	Prunus avium	Acer pseuplatanus	Fraxinus excelsior	Picea excelsa	Abies alba	Larix decidua	Pinus silvestris
Quercion robori-petraea	░	░	░		░							░
Carpinion betuli	░	░	░		░	■	░	░				
Alno-padion		░	░			■	░	░				
Corylo-populion			░	░			■	■				
Fagion-silvaticae					■	░	░	░	▦	▦		
Lunario-acerion							■	■				
Vaccinio-piceenion			░						■	■		
Rhododendro-vaccinion											░	
Ononido-pinion												░
Deschampsio-pinion												░

■ Typical species of the alliance (a) ▦ Species contributing to the alliance (b) ░ Species present in the alliance (c)

FIG. 4.– Phytosociological analysis.
Analyse phytosociologique. (a) espèces caractéristiques de l'alliance, (b) espèces différentielles, (c) espèces compagnes.

FIG. 5.– Ligneous recolonization models.
Modèles de recolonisations ligneuses.



EXTERNAL ALPS

The external Alps are characterized by a short stage of deciduous trees
We have a mixed forest with *Abies alba, Fagus silvatica*
Important rainfall, climatic species are dynamics

INTERMEDIATE ALPS

We observe a large presence of deciduous trees because of :
- numerous hedgerows containing the three species which were commonly exploited for feeding cattle during winter
- a favourable geology (schysts, flyschs) resulting in deep and cold soils
- propitious bioclimatic situation
- large areas of fallow land

INTERNAL ALPS

The deciduous trees are found only in the damp stations
There are severe bioclimatic conditions (low rainfall)
The vegetation is xeric with *Pinus silvestris*

Gams indexes : Gs Gams summer, Gw Gams winter

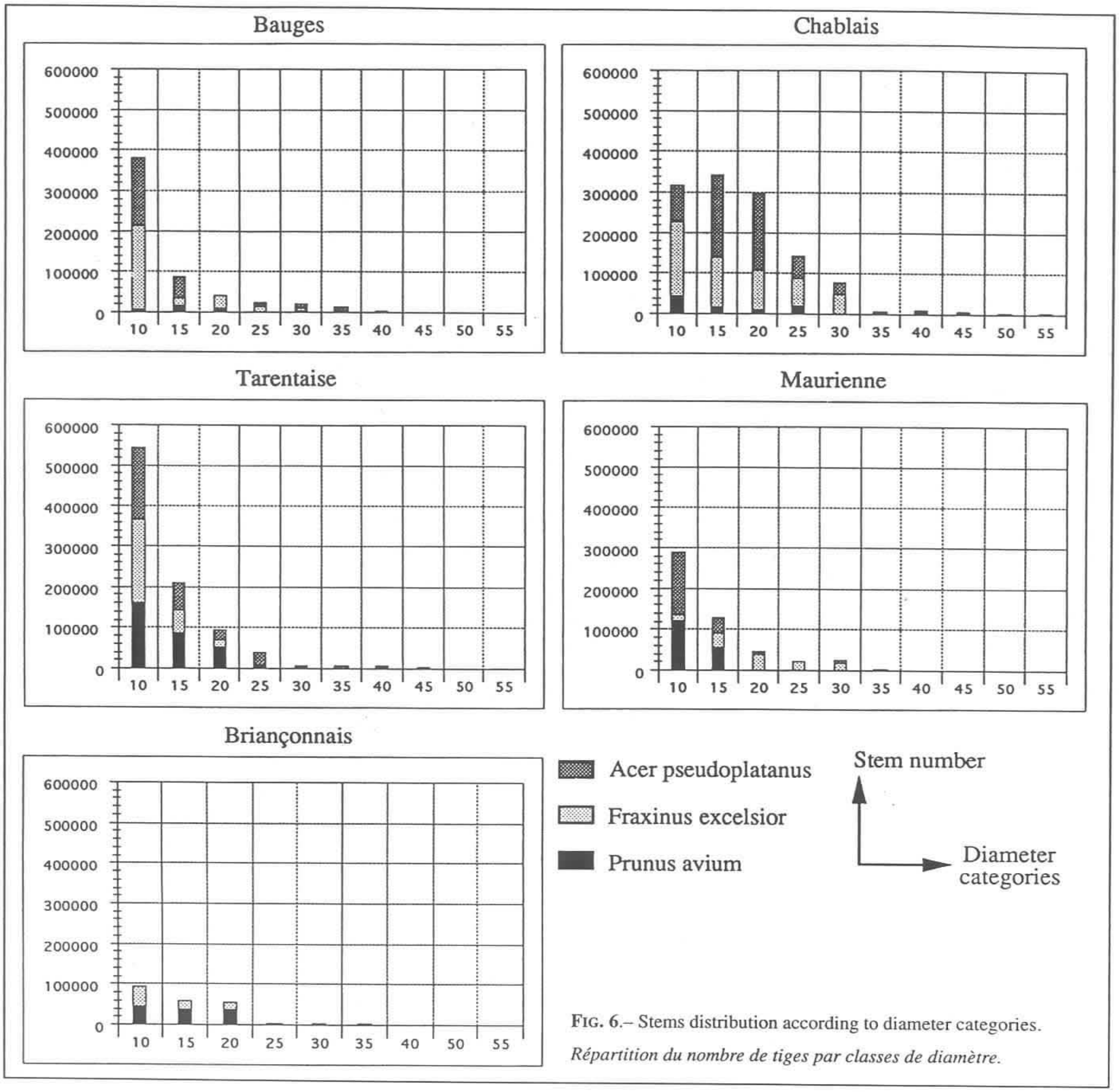


FIG. 6.– Stems distribution according to diameter categories.
Répartition du nombre de tiges par classes de diamètre.

HUMUS PROFILES AND SOIL ACTIVITY INFORMATIONS

Humus forms were studied in all these bioclimatic situations. The first finding is that humus retains its agricultural past even after 30 or 40 years (homogeneity of the arable zone), and all the cases we have described belong to the MULL's group. This humus form is caracterised by a well developed structure (clay-mineral complexes) due to mixing activity of soil-dwelling earthworms (BERNIER & PONGE, 1994 ; GROSSI & BRUN, 1995).

A simple analysis points out an obvious difference throughout all these areas : the litter type (TOUTAIN, 1987 ; GROSSI, 1991).

Two remarks can be made :

- the floristic groups associated with our three species are different in the three bioclimatic areas described. Some species like *Sorbus aria (L.) Crantz, Betula pendula Roth, Populus tremula L.* are more common in the internal Alps, and similarly in the external Alps *Tilia cordata Mill., Carpinus betulus L.* are more represented. These species show extremely different biodegradable and trophical qualities (the amount of brown pigments and polyphenols are different) which explain the more or less rapid turn-over (one year for ash, two years for lime, from two to four years for birch or aspen (ELLENBERG, 1988 ; KRAPFENBAUER & GASCH, 1989).

- this finding is further supported by the fact that the damp season is shorter in the internal Alps, rapidly creating bad conditions for the soil fauna (FITTER & SANDERS, 1992) which enter into diapause until better conditions reappear. The short periods of wetness don't favour microbial activity which, it is well known, transforms the litter. In the external Alps, these phenomenon occur over a longer period, a high turn-over is observed and accumulation of litter is sparse.

Earthworms were sampled in all these areas but for the moment only the Maurienne case has been treated. The results show that in different hydropedological situations the Lumbricidae populations are different.

- In forest stages, under wet conditions, they are more numerous.
- In dry plots, they prefer the fallow land where they are abundant.

DISCUSSION

Our hypothesis is that the commercially valuable deciduous trees appear and maintain themselves according to the three following models (FIG. 5).

- In the external Alps, the deciduous trees are distributed in the old forest (mature stages), and have been installed for a long time.
- On the contrary, in the intermediate Alps, the three species are grouped in the fallow land and have been more recently settled.
- In the internal Alps the ecological conditions restrict their development in space and time.

We must keep in mind that our aim is to explain the distribution of commercially valuable deciduous trees in the French Alps. That is why we introduce the results of two others sites. Recorded data in five different sites allow us to estimate the ages and to reconstitute the installation history of these species.

Five graphics are presented (FIG. 6). They show the stems distribution into the diameter categories for the planting type where the three species are more highly represented (fir, spruce woodlands for the Bauges, beech forest with spruce for Chablais, fallow land for Maurienne and Tarentaise, fragmented woodland for Briançonnais).

These diagrams show differences between the situations.

In the intermediate Alps : Maurienne, Tarentaise, stems are regrouped into low values (10-15 cm). Bauges values have a similar distribution but they are grouped into typical external Alps planting types (FIG. 3).

For the external Alps (Chablais), we can see a spreading of the values until 55 cm and a maximum near 15-20 cm.

All the graphics (except the Chablais) depict the beginning of a ligneous colonisation process from some isolated seed-producers (exponential phase). The Chablais values show natural regeneration process based on the distribution of mature trees distributed in the whole area.

Genetic variability could be discussed here. *Fraxinus* genus is extremely weak in the chloroplastic D.N.A. sequences. As GIELLY (1994) has shown throughout the Alps, the ecophysiological behaviour differences (established on the plots) are only phenotypic variations.

In fact, the different models could be better explained by a combination of landscape pattern and species behaviour.

CONCLUSIONS

Post-pioneer deciduous trees behave differently according to the bioclimatic situations of the French Alps.

In the external Alps, they are distributed with low density, in relation with the climax species. In the intermediate Alps, the deciduous trees are well developed especially on the south-facing mountainsides, where the competition of resinous trees is weak ; the internal Alps stands are limited on wet situations where are excluded the scots pine.

This research shows that in some of the areas studied (Maurienne and Tarentaise valleys), the importance in the development of ash, sycamore maple and wild cherry is considerable. They're todays responsible for a closed landscape. It's now essential to value the development of these species. Failing the prevention of ligneous colonisation, this phenomenon must be managed and organised. Until yet, this research as generated some local actions for the valorisation of the ligneous biomass.

The scientific interest of these studies remain high. Postpionner forest stages are buffer stages between open fields and mature forests. More detailed description would ensure a better knowledge of the evolution of the vegetation structure, floristic composition and species behaviour along the dynamic stages (MILES, 1979).

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VERSION FRANÇAISE ABRÉGÉE

La déprise agro-pastorale, accentuée depuis le début du XXème siècle, entraîne la recolonisation des espaces abandonnés par des formations ligneuses. A l'étage montagnard, cette dynamique végétale favorise actuellement l'apparition de formations caducifoliées composées d'espèces dites « précieuses » : *Fraxinus excelsior L., Acer pseudoplatanus L., Prunus avium* L.

Le but de notre étude est d'établir et de comprendre la distribution des feuillus précieux dans les Alpes françaises en fonction des facteurs environnementaux (climatologie, géologie, géomorphologie) qui gouvernent leur répartition dans l'espace.

Nous avons choisi de travailler sur huit régions réparties sur l'ensemble des Alpes occidentales françaises. Parmi celles-ci, trois zones sont bien représentatives : les Bauges (Alpes externes), la Maurienne (Alpes intermédiaires) et le Briançonnais (Alpes internes). Notre méthode d'étude est basée sur l'analyse de données statistiques, phytoécologiques et pédobiologiques.

Nous avons utilisé des données statistiques de l'Inventaire Forestier National portant sur les différentes régions forestières. Nous avons d'abord étudié la répartition des trois espèces dans chaque zone d'après le nombre estimé de tiges, puis leur appartenance aux différents types de peuplements. Ces résultats sont ensuite pondérés par rapport aux surfaces boisées. Trois situations apparaissent : dans les Bauges (Alpes externes), le taux de boisement est élevé (59,1 %) et la surface boisée est occupée principalement par les hêtraies, sapinières et pessières. Les feuillus précieux sont présents dans pratiquement tous les stades forestiers et également dans tous les stades de la dynamique. Dans la vallée de la Maurienne (Alpes intermédiaires), le taux de boisement est plus faible (17,2 %), les feuillus précieux sont bien développés dans les accrus et ils couvrent de grandes surfaces sans être mélangés aux autres espèces. Enfin, le Briançonnais est caractérisé par une absence presque totale des feuillus (2,5 % de la surface boisée de production) ; le merisier en est complètement absent, le frêne et l'érable restent marginaux dans cette région.

Pour l'approche phytoécologique, nous avons effectué des relevés floristiques effectués dans les différents sites. Ceux-ci ont été comparés aux données de la littérature pour préciser la situation phytosociologique des trois espèces étudiées. Celles-ci connaissent un optimum dynamique (l) dans les Alpes intermédiaires, (2) dans les stades de transition des successions post-culturales. Les données IFN confirment ce résultat.

Dans le domaine pédobiologique, nous avons étudié l'humus, la litière et la faune du sol. L'importance du climat semble évidente aussi bien sur le type d'activité que sur la période durant laquelle elle se manifeste mais également sur la maturation (minéralisation et humification) des litières. Les lombriciens, qui ont fait l'objet d'une étude plus approfondie, permettent de valider ces affirmations.

Dans certaines régions étudiées (les vallées de la Maurienne et de la Tarentaise), le développement de ces espèces est considérable. Elles sont responsables de la fermeture du paysage à l'étage montagnard. Il est donc très important, dès à présent, d'évaluer leur extension. A défaut de prévenir la colonisation ligneuse, ce phénomène doit être connu et géré.

Ces stades forestiers présentent certes un intérêt commercial non négligeable, mais l'aspect scientifique n'en est pas moins primordial. La description et l'étude de ces peuplements de transition nous apporteront des éléments pour une meilleure connaissance de la dynamique végétale : structure de la végétation, composition floristique et espèces futures.